VOL. XV. NO. 12.—BOTANICAL GAZETTE.—DEC., 1890.

Notes on the development of Tubulina cylindrica and allied species of Myxomycetes.

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That part of the life cycle of the curious and ever interesting Myxomycetes, which includes the formative plasmodium and its subsequent stages of development into mature sporangia, has been the subject of extensive physiological study in the laboratory, but has been as yet but little considered by the systematists.

Notwithstanding the anomalous character of the origin and development of these marvelous organisms, their generic and specific limits are practically well defined and apparently as stable as in any other natural group. This is essentially true, even though the sporangia of the mature Myxomycetes manifest a well marked tendency to variation of form, color and structure which seems to characterize some genera especially, while only exceptionally found in others.

Excessive as this variation is in some cases, it may be found by careful field work or by an analysis of a large number of specimens to fall within specific lines, and to be due mainly to local external influences.

Many causes operate to produce these results in the mature sporangia, the most active being the varying or extreme degrees of temperature and atmospheric moisture to which they are exposed. During a period of several days of great warmth combined with great humidity, the plasmodium will develop rapidly and multiply with wonderful exuberance, causing the resulting sporangia to lose their possibly simple normal character and become clustered, distorted or plasmodiocarpous in form. Climate, the season of the year, or what may have practically the same effect, the altitude of habitat, will cause a difference in the time of development from plasmodium to maturity, of from twenty-four hours in some cases to nearly a week in others, with a corresponding difference in results.

As a familiar example of this, Hemiarcyria clavata developed in the hot days of July and August will erect quickly into scattered, globose, long-stiped sporangia which rupture

immediately as they dry, leaving scarcely a vestige of a receptacle, while the same species late in October will develop closely aggregated, obovate, almost clavate sporangia, nearly sessile or with quite short stipes, which rupture slowly several days after maturity, leaving a very deep funnel-shaped receptacle.

Among the Calcareæ, the amount of lime in solution available for the use of the plasmodium will greatly influence the degree to which lime granules are found in the capillitium and sporangium walls, thus producing great apparent variation in structure. Careful examination in these cases, however, will show that the essentials of structure are the same, and the amount of lime only a variable and non-important factor.

In the plasmodial stage of the Myxomycetes, however, no such tendency to variation exists, and the plasmodium of every species which I have observed is unvarying in color and other physical characters. It is true, the normal color may be temporarily affected by adventitious coloring matter picked up by the plasmodium during its amœboid wanderings and absorbed into its mass, but these particles are soon excreted or deposited, and have no permanent influence.

To cite a few of the familiar and better-known species out of many which could be given: Fuligo varians always develops from a rich yellow plasmodium, Dictydium cernuum from a purple-black, Leocarpus fragilis from a reddish orange, Chondrioderma floriforme from a gray or drab, the Arcyrias and many others from an uncolored or white plasmodium, and so on without any exception that I have noted.

The question of the constancy of the color changes in the stage following the plasmodial, that of the differentiation and development of sporangia, is more difficult of determination, because it is a progressive stage, one of variable duration, and one susceptible to external influences. Nevertheless, I believe it to be equally true that the color of the corresponding stages of development of the individual sporangia, from plasmodium to maturity, is always the same, varying only in duration and intensity according to local conditions.

If this view be strengthened by further observations, it can not be doubted that a knowledge of the color and character of the plasmodium, and of the color changes in the transitional period from the plasmodic to the mature stages of the Myxomycetes, is of diagnostic value, and may, under certain conditions, be essential to the correct determination of species and their relations to each other.

The following observations upon *Tubulina cylindrica* (Bull.) and allied species are given as a contribution to their life histories, with special reference to the points above noted:

Tubulina cylindrica, as found in the eastern part of the United States, varies greatly in external appearance. By a careful examination all mature specimens, including unusual forms or variations, found in this area, may be separated into two groups by their external differences only. These differences, however, relate only to such characters as density and color, which, in the mature sporangia, have no essential value as points of specific difference, the sporangia of the two groups being morphologically the same.

During the summer of 1889, while in the Adirondack mountains, N. Y., I had the opportunity of observing the development of typical examples of each of these forms from the plasmodium through all the intermediate stages of growth to maturity, under similar local conditions. I had previously noted developmental differences, but on the present occasion the forms under comparison grew simultaneously on adjoining logs, thus having the same relative conditions of temperature, atmospheric humidity and moisture of subjacent log surface to influence their growth. Both forms originated from a white or uncolored plasmodium, but from this point the corresponding stages of differentiation and erection of the respective sporangia to complete development and maturity were notably different in color and character.

The contrasting external character of mature specimens of these types may be described as follows:

Form no. 1 is composed of an aggregation of cylindrical sporangia, sessile, standing on a common hypothallus, individual sporangia either free or united wholly or in part by their walls, apices rounded or conical, very fragile in structure, breaking at the slightest touch, light brown or chestnut brown in color. This is the type of the common *Tubulina cylindrica* (Bull.) and is found probably in all parts of the United States.

Form no. 2 is an æthalium composed of an aggregation of cylindrical sporangia becoming many-sided by mutual pressure, sessile, standing on a common hypothallus, always (or with rare exceptions) united the entire length of the sporangia, the apices flattened, making in continuation a nearly plane and vernicose surface of considerable density of structure, dark brown or umber in color. The entire structure of the sporangia of this form is markedly denser and darker than in the other. I have as yet found it only in the

mountain regions of New York or Pennsylvania. The spores in both forms are practically the same, the only difference being due to the thicker and darker epispores of form no. 2. The epispores are similarly sculptured, showing characteristic irregularly meshed reticulations under a high power.

The differential stages of development of the two forms from the plasmodium, showing the color changes, may also be tabulated as follows:

Form no. 1 originates in an uncolored or white plasmodium, erects into bright rose or strawberry red immature sporangia, and then shades into the light-brown or chestnut-brown color of maturity.

Form no. 2 originates in an uncolored or white plasmodium, erects into dark raspberry or mulberry red immature sporangia and then shades into the dark brown or umber color of maturity.

These comparative differences in color appeared in all cases which I have had the opportunity of observing. In individuals of the same type the color varies only in intensity or brightness, not in tone, according to the degree of moisture present in the atmosphere or in the substratum. An excess of moisture, such as may be caused for instance by heavy rains falling upon the immature sporangia of any of the Myxomycetes, will render them dull and lifeless in color, imparting a faded or washed-out appearance.

A correct appreciation of color distinctions depends so largely upon the personal equation of the observer that I feel conscious that the foregoing changes may not have been sufficiently described, but the point desired to be specially noted, is that each of the above forms, and those yet to be described, has a distinct series of color changes which characterizes its immature period of growth. The differences in development just noted would be better appreciated if seen than described, and, considered in connection with the conspicuously different external appearance of the two forms, will justify the belief of a physiological specific distinction between them. At the same time these forms are morphologically similar, and as sufficient herbarium characters available for classification in separate species are lacking, they will probably still be referred to the same species by systematists.

It seems fitting that the developmental history of the following species, allied to Tubulina cylindrica, should also be recorded with it:

Tubulina stipitata B. & C. This species originates from

an uncolored or white plasmodium, erects into salmon or buff colored immature sporangia, and then shades into the chestnut umber color of maturity. .

This species is not always stipitate, although it was so described by Berkeley. Sessile specimens are not uncommon, and in many instances they are found associated with others which are stipitate or sub-stipitate, all having the same small, characteristic spores.

Siphoptychium Casparyi Rostfki. This species originates from an uncolored or white plasmodium, erecting into immature sporangia of a dull gray, tinged with sienna color, and then shades through various tones of sienna brown to the dark brown or umber of maturity.

A large æthalium of this species approaching maturity suggests a curious and striking similarity in color to a beautifully browned roll or loaf of bread, and as it generally grows upon the surface of a moss-covered log, it makes a conspicuous object.

Although the necessities of a systematic arrangement apparently led Rostafinski to place the genus Siphoptychium in his order Columelliferæ, it undoubtedly bears a closer relation to the genus Tubulina than to any other, and should be classified with it or near it. The spores are of the characteristic Tubulina type, with the epispores sculptured with an irregularly meshed reticulation. The sporangia much resemble externally those of Tubulina cylindrica (form no. 2), but differ from them in being provided with a central tubular columella from which radiate a few threads or tubules, like stays connecting it with the walls of the sporangia. By a careful examination it may be seen that these columellas and radial tubules are apparently the remains of individual sporangia aborted in the course of the evolution of the genus, and are not of the same character as the columellas and threads of other members of the Columelliferæ. In partial corroboration of this view, may be cited the fact that æthalia of Siphoptychium are found, in which from one-third to one-half of the component sporangia lack both columellas and connecting threads, resembling so far the genus Tubulina.

Moreover, I have in my possession a specimen of Tubulina cylindrica (form no. 1), in which can be seen a number of sporangia which have either vertical membranous septa or threads crossing from side to side. There are also a few contracted or aborted sporangia which serve as columellas, in the center of larger ones, to which they are united with

threads or tubules, indicating an evolutionary approach toward the genus Siphoptychium.

For these structural reasons, and also by reason of analogous development, the genus Siphoptychium, notwithstanding its present position in the classification of its author, has been treated in this paper as allied to the genus Tubulina.

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Notes upon Peronosporeæ for 1890.

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The season just closing has been a moderately wet one in New Jersey, but the excess of rainfall did not equal that of last year. This statement that we have had two succeeding wet years is an important one in this connection. All of the ordinary forms of the order Peronosporeæ have been abundant, and only a word will be said of a few of the leading species, as there are a number of new hosts for old forms and some species new to America to be herein recorded.

Phytophthora infestans D'By., causing the wet rot of the white potatoes, has been most strikingly destructive this autumn, especially in the southern counties of the state. So abundant has it been that thousands of acres that otherwise would have yielded a large crop will not be dug at all. Slices of the rotting potatoes placed in moist chambers developed the conidiophores and spores in four hours. This gives some idea of the rapidity with which this fungus runs its course, always a surprise as well as source of dismay to the growers.

The *Phytophthora Phaseoli* Thax., first found last season by Dr. Thaxter in Connecticut, has been frequently looked for but not obtained upon any sort of cultivated bean. This new member of the small genus may as yet be quite local in its range, but is expected in sight at any time.

Plasmopara viticola (B. & C.) Ber. & DeT., has been abundant upon the grape. In one vineyard where hundreds of clusters had been ruined by this mildew, after a long search none could be found upon the leaves. This is so unusual that it is worthy of notice. In this connection it may be said that specimens of succulent galls of the stem and leaf-stalks were sometimes found completely covered with the Plasmopara, while other parts were entirely free. This indicates that the soft gall tissue furnishes better conditions